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REVIEW AND SYNTHESIS

Biocultural approaches to sustainability: A systematic review of the scientific literature

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Abstract

1. Current sustainability challenges demand approaches that acknowledge a plurality of human–nature interactions and worldviews, for which biocultural approaches are considered appropriate and timely.
2. This systematic review analyses the application of biocultural approaches to sustainability in scientific journal articles published between 1990 and 2018 through a mixed methods approach combining qualitative content analysis and quantitative multivariate methods.
3. The study identifies seven distinct biocultural lenses, that is, different ways of understanding and applying biocultural approaches, which to different degrees consider the key aspects of sustainability science—inter- and transdisciplinarity, social justice and normativity.
4. The review suggests that biocultural approaches in sustainability science need to move from describing how nature and culture are co-produced to co-producing knowledge for sustainability solutions, and in so doing, better account for questions of power, gender and transformations, which has been largely neglected thus far.

KEYWORDS

bio-cultural, conservation, knowledge, social–ecological systems, Sustainable Development Goals, transformation, values

1 | INTRODUCTION

Biocultural approaches to sustainability are gaining attention in academia as ways of simultaneously representing, interpreting and shaping human and cultural dimensions of complex social–ecological systems (Merçon et al., 2019) . Although the concept originates from the field of biological anthropology, where it has mainly been used to describe the effects of social environments on human health and biology, the actual application is much broader and elusive (Wiley & Cullin, 2016). From anthropology, the concept has been spreading to other fields and the definition of the concept has shifted away from human biology towards an emphasis on the tight interlinkages between human societies, particularly their cultural sphere, and the natural and biophysical environment in which they exist. Most prominently, this development gave rise to the idea of biocultural diversity that has been defined as the 'diversity of life in all its manifestations—biological, cultural and linguistic—which are interrelated within a complex socio-ecological adaptive system' (Maffi, 2005, p. 602). The term biocultural diversity has partly been confined to the realm of indigenous and local people's worldviews and livelihood strategies and their effects on biodiversity. However, it has also been argued that more attention should be given to the cultural values and practices of communities and human populations in transformed rural areas and urban landscapes (Buizer, Elands, & Vierikko, 2016; Cocks, 2006).

Diverse ontological, epistemological and ethico-political dimensions of biocultural approaches have also been stressed by different sectors of academia, practice and global environmental policy-making (Merçon et al., 2019). Most importantly, biocultural approaches have gained ground recently, because they are seen as well suited to address sustainability challenges. Thereby they are part of a broader shift from a unidirectional utilitarian conceptualization of nature and narrow disciplinary solutions, towards more systemic and inclusive approaches that acknowledge a plurality of worldviews and human–nature interactions (Maffi & Woodley, 2010; Merçon et al., 2019; Pungetti, 2013). These features potentially also include participatory, transdisciplinary approaches that take into account multiple evidences in knowledge production processes and governance for sustainability (Raymond, Kenter, Kendal, van Riper, & Rawluk, 2019), and are inclusive of different ways of knowing, especially through incorporating lay and non-scientific knowledge from diverse actors, thus enabling a genuine co-production of knowledge (Tengö, Brondizio, Elmqvist, Malmer, & Spierenburg, 2014).

The need to respect and take into account diverse forms of knowledge and worldviews was expressed prominently towards the broader public as early as 1988 through the Declaration of Belém (Declaration of Belém, 1988) and the following decades brought an increasing uptake of biocultural approaches in global sustainability policies. The Convention on Biological Diversity (CBD, 1992), for example, required that the knowledge, practices and innovations of indigenous and local communities that are relevant for the sustainable use of biological resources should be respected, preserved and maintained. More recently in 2010, UNESCO and the CBD launched a joint programme on biological and cultural diversity (www.cbd.int/lbcd/), which led to further recognition of biocultural diversity (e.g. through the Florence Declaration produced in 2014). Increasingly, it has been demanded for science-policy forums to become more inclusive and incorporate different perspectives and worldviews, as illustrated by the efforts of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES; Díaz-Reviriego, Turnhout, & Beck, 2019; Turnhout, Bloomfield, Hulme, Vogel, & Wynne, 2012), as well as processes for navigating diversity and conflict among them (Kenter et al., 2019). The IPBES global assessment highlights the role of indigenous and local communities in managing and preserving biodiversity and ecosystem services (IPBES, 2019) and the IPBES assessment on pollinators and pollination illustrates how biocultural approaches can guide governance and practice in this endeavour (Hill et al., 2019). Precisely by its ability to bridge diverse knowledge systems and policy, biocultural approaches could become powerful tools in the pursuit for sustainability (Merçon et al., 2019; Sterling et al., 2017). However, biocultural approaches are typically referred to in a broad and vague way, and it yet needs to be explored how they are applied and how they actually can unfold their potential for finding much needed sustainability solutions.

For this review, we focus on the contributions of and potential for biocultural approaches in advancing sustainability science (Kates et al., 2001). Very broadly, we interpret sustainability science to include all research that is concerned with sustainability issues (not necessarily assuming that the authors of the research articles analysed would self-identify as sustainability scientists). We assessed how the literature engages with the main principles of sustainability science, the inclusion of different knowledge types through inter- and transdisciplinarity and the attention to social justice issues and the consideration of normative goals as represented by the Sustainable Development Goals (SDGs; UNGA, 2015).

Our assessment complements recent reviews of biocultural approaches that have focused on the theoretical perspectives underpinning these approaches and the different biocultural discourses (Bridgewater & Rotherham, 2019; Cocks, 2006; Merçon et al., 2019). Our aim is to systematically delineate contrasting conceptions and applications of biocultural approaches in sustainability research to gain a clear and thorough understanding of the diversity of perspectives on biocultural approaches available in the scientific literature. This understanding will allow for a greater appreciation for the richness and complementarity of the different biocultural approaches, promote interdisciplinary debates around these approaches and help to unfold their full potential in future applications in sustainability science.

2 | METHODOLOGY

We queried the Scopus database with the search strings 'biocultural' or 'bio-cultural' in Title, Keywords, Abstract for publications between 1990 and 2018. The query returned 1,359 publications. Other

databases than Scopus were not considered as we were interested in gathering the scholarly literature on the topic that has been published in international journals, acknowledging the limitations of this approach. In a first round of screening, we included only publications related to sustainability and environmental issues, as well as natural resource management, and excluded papers that were purely focusing on topics from palaeontology, theology, psychiatry, human evolutionary biology and biological anthropology. The first screening was split between two authors (J.H., L.J.H.) after an initial joint screening to calibrate the assessment. Screening was cross-checked by a third person (T.P.) on a random subset and on publications where the first screening did not lead to a clear classification (suitable or not). We also excluded non-English articles and all books and book chapters. Thus, the first round of screening yielded a total of 431 scientific articles written in English. Subsequently, we did a second round of screening based on the full text, where we classified publications according to the depth of engagement with biocultural approaches. For this, we classified all publications into either only mentioning the term as a buzzword or only very generally making a connection without actually engaging with the concept, and into papers that engaged in depth with biocultural approaches, dedicating substantial parts of the paper to it (see Figure 1). This second round of screening yielded a set of 178 papers with a primary focus on biocultural approaches, which we included in the review (see Figure S1 in the Supporting Information for a detailed description of the selection criteria in a flow chart. A list of the reviewed papers is available in the Data Sources section).

The review process was a combination of deductive and inductive and quantitative and qualitative approaches in order to gain a rich understanding of the available literature. Deductive coding was done for 12 different predefined categories, which are summarized in Table 1. For each of the categories we calculated descriptive statistics.

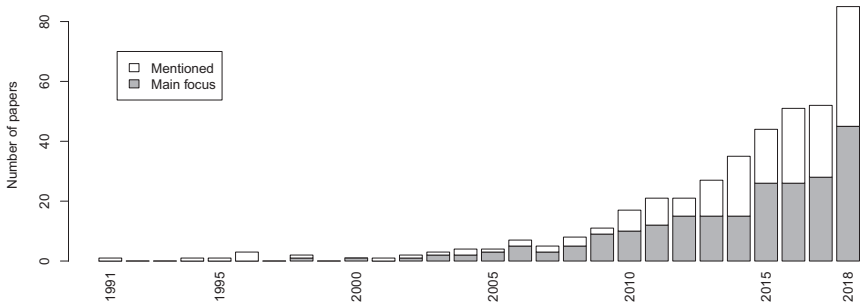

FIGURE 1 Number of publications that either only shortly mention 'biocultural' or have it as the main focus. Only papers with the main focus on biocultural approaches were included in this review

TABLE 1 Categories used for deductive coding of the articles

Name	Description	Data type
Type of paper	What type of paper is it?	Categorical (conceptual, discussion, empirical, review)
Emphasis	Does the study mainly focus on cultural (or social) aspects or on biological (or ecological) aspects?	Ordinal (1—purely cultural; 2—mainly cultural; 3—balanced; 4—mainly biological; 5—purely biological)
Focus	Does the study emphasize preservation/conservation or dynamic/transformation of biocultural components?	Ordinal (1—conservation; 2—balanced/mixed; 3—transformation)
Knowledge type	Focus on which type of knowledge	Ordinal (1—local/traditional; 2—mixed; 3—scientific)
Value type	Which type of value (Chan et al., 2016) does the paper focus on?	Categorical (instrumental, relational, intrinsic)
Power	Does the study consider power? If yes, how?	Dummy (yes/no)
Gender	Does the study consider gender? If yes, how?	Dummy (yes/no)
Action	To which degree is the paper a call for (participatory) action?	Ordinal (0—not mentioned; 1—mentioned but not the main focus; 2—action is the main focus)
Governance	Which types of governance and decision-making is emphasized?	Categorical (not considered, bottom-up/decentralized, polycentric/multilevel, top-down/centralized)
Sustainable Development Goal (SDG)	To which main Sustainable Development Goal does the paper refer to?	Categorical (0 = no reference; goals 1–17)
Transdisciplinarity	To what extent are non-scientific actors involved in the research process (Brandt et al., 2013)?	Ordinal (0—no involvement of non-scientific actors; 1—informed by/consultation of non-scientific actors; 2—collaboration with/empowerment of non-scientific actors
Scientific discipline	Which discipline does the study most strongly connect to? (based on author affiliation or journal; following the classification of the German Research Foundation DFG with the addition of Sustainability Science	Categorical (agriculture, forestry and veterinary medicine; biology; construction engineering and architecture; geosciences; humanities; social and behavioural sciences; sustainability science)

Coding was equally split between multiple authors and inconsistencies or questions were discussed. Inductive coding was performed in two rounds. We split the first round of coding between multiple authors (A.S.O., N.M.G., C.M.R.) assessing how 'biocultural' was defined and what motivated the concept's application in a given paper. Facilitated through a series of deliberative discussions within a workshop setting, this led to the establishment of nine different codes. In a second round of coding, done by a single person (J.H.), these nine codes were refined to a final set of seven codes, which were then discussed with all authors involved in the first round of inductive coding. Subsequently, we called these inductive codes 'biocultural lenses', or in other words, different ways of understanding and applying biocultural approaches to sustainability. Hence, we use the term 'biocultural lens' as a shared epistemological approach. Recognizing that papers rarely can be assigned to a single lens and aspects from different lenses can co-occur within a single paper, we distinguished between primary lenses, that is, the main affiliation of a paper to a lens, and secondary lenses, that is, other lenses that a paper could be assigned to.

In addition to presenting the identified lenses, we quantitatively analysed the lens assignment using a multivariate analysis. Specifically, we applied a detrended correspondence analysis (DCA) of the coded lenses based on a matrix with a value of 1 for a primary lens and 0.5 for secondary lenses. In order to understand how the resulting pattern relates to other characteristics of the papers, we used a post hoc test to assess the correlation of the ordination space with variables from the deductive coding (Permutation test with 9,999 permutations and a significance level of 0.05).

3 | RESULTS

3.1 | General overview

We reviewed a total of 178 papers that had a primary focus on biocultural approaches (Figure 1), most of which were empirical studies (*N* = 104; Figure 2a). Papers usually considered biological and cultural aspects simultaneously, but there tended to be greater emphasis on the cultural dimension (Figure 2b). Most prominently, papers focused on conservation of biocultural aspects (*N* = 99) and only rarely on transformational change (*N* = 19; Figure 2c). Knowledge types tended to be mixed, but some papers only considered indigenous/traditional (*N* = 59) or scientific knowledge (*N* = 36; Figure 2d). Relational (*N* = 130) and intrinsic values (*N* = 59) were commonly addressed (Figure 2e). The majority of papers did not consider power (*N* = 119; Figure 2f) or gender issues (*N* = 142; Figure 2g). Although recommendations for action were often mentioned (*N* = 80), action was less frequently the main focus (*N* = 43; Figure 2h). In many papers, governance was not considered as a relevant aspect (*N* = 80), while in others polycentric governance (*N* = 54) was mentioned (Figure 2i). Approximately half of the papers (*N* = 84) were not based on a transdiciplinary engagement, one-third of the papers (*N* = 63) shared information or consulted non-academic actors and only 31 papers were deeply engaged through collaboration or empowerment (Figure 2j). Most of the papers were from the fields of biology (*N* = 49), agriculture, forestry, veterinary medicine (*N* = 43) and the humanities (*N* = 34). The main aim of the papers could most often be linked to Sustainable Development Goal 15 ('life on land', *N* = 73; see Figure 3), followed by Goal 11 ('sustainable cities and communities', *N* = 12) and Goal 2 ('zero hunger', *N* = 12).

3.2 | Biocultural lenses

Through primary inductive coding of the definition, motivation and application of biocultural approaches, we identified seven different biocultural lenses. In the following paragraphs we summarize the main characteristics of these lenses.

3.2.1 | Biocultural diversity

This lens (37 papers) uses the concept of biocultural diversity as the central element. It includes papers that conceptualize and define biocultural diversity (Elands et al., 2018; Maffi, 2005), but also papers that redefine it (Cocks, 2006), papers that expand its application, for example, to invasive species (Pfeiffer & Voeks, 2008) or describe additional ways of its description, for example, through arts (Polfus et al., 2017). Furthermore, it includes papers that assess the logic and type of the connection between nature and culture, which is implemented by the idea of biocultural diversity (Frascaroli, 2016; Grant, 2012). This lens also contains studies that develop indicators of biocultural diversity (Loh & Harmon, 2005; Winter, Lincoln, & Berkes, 2018) or describe specific components of biocultural diversity (Polfus et al., 2016; Stepp et al., 2004). Also, the *biocultural diversity* lens includes papers that describe the rationale for why biocultural diversity can be important for sustainable development (Sadowski, 2017).

3.2.2 | Biocultural conservation

The *biocultural conservation* lens (24 papers) emphasizes some kind of conservation and its implementation and improvement. Papers within this lens range from improving biodiversity conservation with biocultural methods (Caillon, Cullman, Verschuuren, & Sterling, 2017), to the need to simultaneously achieve biological and cultural conservation (Dunn, 2008; Ens, Scott, Rangers, Moritz, & Pirzl, 2016) to genuinely conserve biocultural diversity (Hill, Cullen-Unsworth, Talbot, & McIntyre-Tamwoy, 2011; Rozzi, 2012a; Rozzi, Massardo, Anderson, Heidinger, & Silander, 2006). The role of indigenous peoples in the co-management of conservation areas is an example of how empowerment of local communities and conservation of cultural aspects can contribute to successful biodiversity conservation (Stephenson, Berkes, Turner, & Dick, 2014). Notably, some of the other lenses (e.g. *biocultural diversity*, *biocultural history and heritage*, *biocultural knowledge and memory*) also make connections to conservation, but only here it is the main focus and therefore also tends to be more strongly action-oriented than the others.

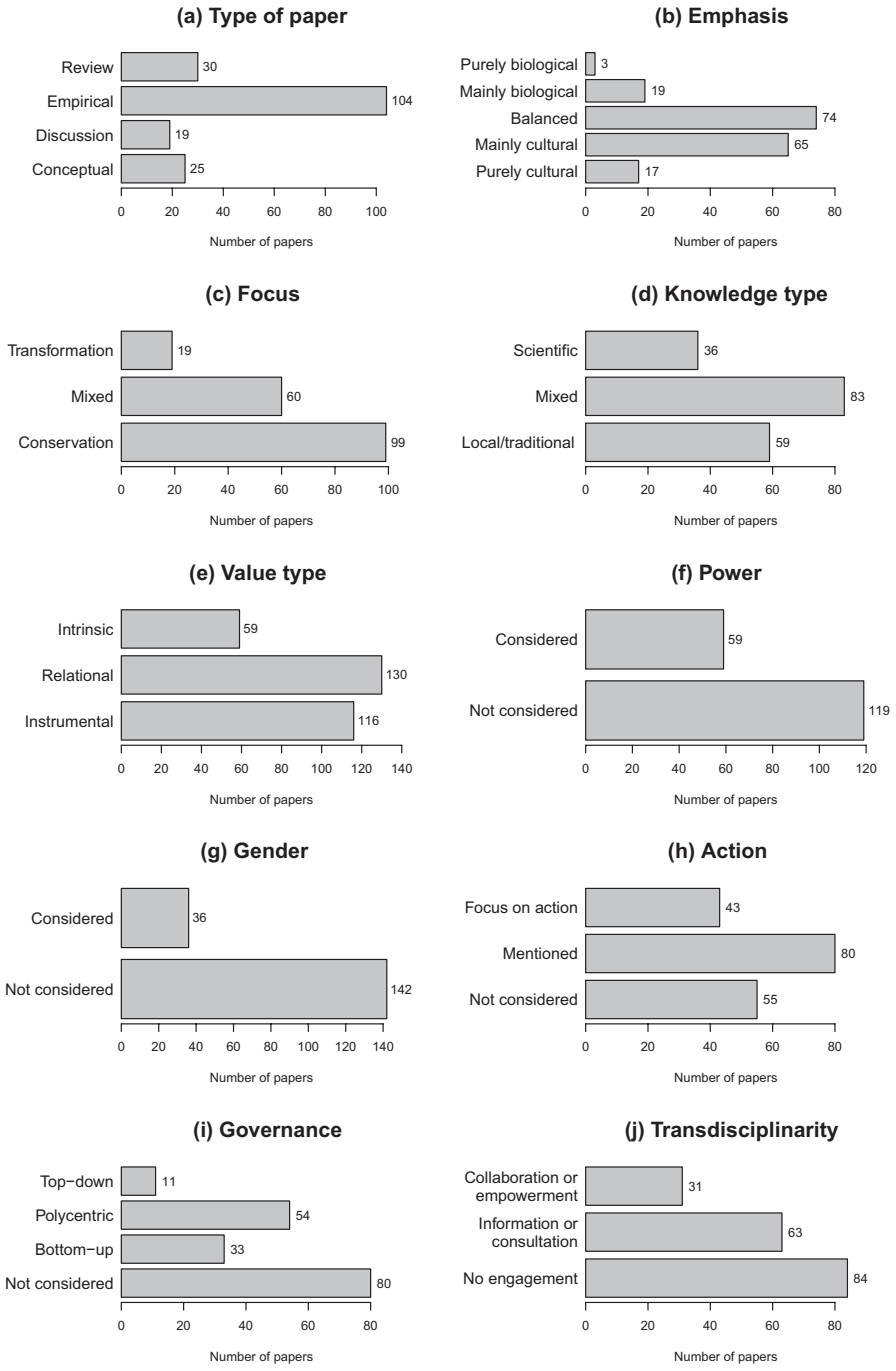

FIGURE 2 Descriptive overview of the characteristics derived through deductive coding. This includes (a) type of paper, (b) main emphasis, (c) focus, (d) knowledge type, (e) value type, (f) consideration of power, (g) consideration of gender, (h) consideration of action, (i) governance type and (j) degree of transdisciplinarity

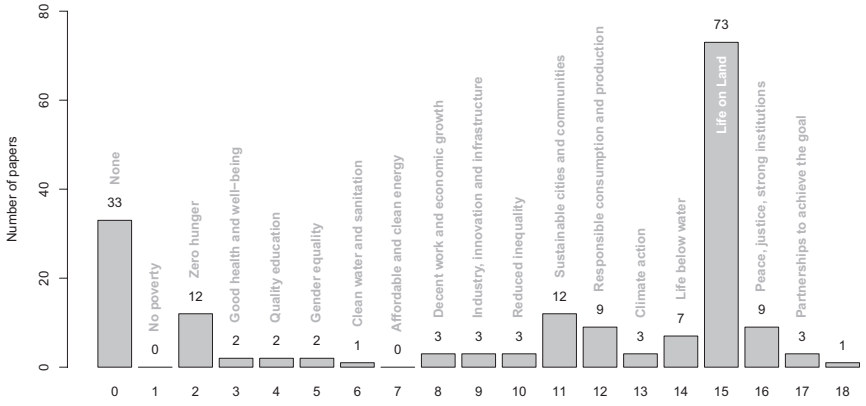

FIGURE 3 Frequency distribution of the main Sustainable Development Goal (SDG) considered by the reviewed papers. If a given paper could not be linked to a specific goal it was counted as zero. One of the papers argued for the need for an SDG 18, which would entail cultural sovereignty and its interconnectedness with biodiversity

3.2.3 | Biocultural landscapes and natural resources management

This lens (35 papers) emphasizes a spatial view and uses the concept of (cultural) landscapes (or seascapes) as a spatial and tangible expression of a long history of human–environment interaction and co-evolution of cultural and biological characteristics, such as biocultural refugia (Barthel, Crumley, & Svedin, 2013). Therefore, such cultural landscapes are often seen as inherently rich in diversity (Bridgewater, 2002) and the need to continue traditional (land) uses such as farming is frequently stressed. In general, there is often a strong connection made to the use (Laird, Awung, Lysinge, & Ndive, 2011) and management of natural resources (Agnoletti & Santoro, 2015). While the papers range from a whole landscape approach to focussing on very specific features of such landscapes, for example, trees and hedges (Fukamachi, Miki, Oku, & Miyoshi, 2011), space is usually taken as the analytical entry point (Ciftcioglu, Uzun, & Nemutlu, 2016), or as an arena of interaction between humans and the environment (Bridgewater, 2002).

3.2.4 | Biocultural history and heritage

The *biocultural history and heritage* lens (18 papers) focuses on temporal dimensions including aspects related to long time horizons, time depth, continuity, legacies and tradition. Typical papers describe historical biocultural diversity (Petrucci et al., 2018), study the co-evolution of biological and cultural diversity (Cevasco, Moreno, & Hearn, 2015; Lezama-Núñez, Santos-Fita, & Vallejo, 2018), describe historical land uses, question the idea of pristine nature, for example, in the Amazon forest (Heckenberger, Russell, Toney, & Schmidt, 2007) and stress that a long history is something valuable that needs to be maintained (Rotherham, 2015).

3.2.5 | Biocultural knowledge and memory

The *biocultural knowledge and memory* lens (38 papers) focuses on knowledge, practices, beliefs and values as expressions of biocultural diversity and a long history of human–environment interaction. Papers in this lens sometimes very specifically focus on individual species (Singh, Srivastava, Padung, Rallen, & Taki, 2012), specific purposes (González, Carvalho, Vallejo, & Amich, 2017), single land use types (Neulinger, Vogl, & Alayón-Gamboa, 2013), certain spatial units, such as watersheds (Iniesta-Arandia et al., 2015) or islands (Kueffer & Kinney, 2017) or how knowledge and memories can be maintained (Aston Philander, Makunga, & Platten, 2011). Usually, papers talk about indigenous or traditional forms of knowledge and memories, and sometimes these are described as gender specific (Cocks, Bangay, Wiersum, & Dold, 2006). The lens also includes papers that relate knowledge to empowerment and participation (Robertson & Hull, 2003) to improve conservation measures and management (Ens et al., 2015; O'Neill, Badola, Dhyani, & Rana, 2017).

3.2.6 | Biocultural ethics, rights and sovereignty

This lens (six papers) puts the main emphasis on issues around justice, rights and sovereignty of local or indigenous people. It tends to be action oriented from a justice perspective. The *biocultural ethics, rights and sovereignty* lens includes papers that very broadly relate to biocultural ethics (Eser, 2009; Rozzi, 2012b) or that are more specific, such as on the matter of legal recognition of traditional knowledge and their holders in international treaties (Srinivas, 2012), as well as on the matter of patenting specific geographical indications (Samaddar & Samaddar, 2010).

3.2.7 | Biocultural restoration, transformation and design

This lens (20 papers) focuses on guiding and implementing change towards desirable futures. It includes papers on biocultural restoration, which also have a strong connection to the conservation lens. Typical papers highlight that the restoration of ecosystems should jointly happen with cultural revitalization (Kurashima, Jeremiah, & Ticktin, 2017), that it should be guided by local knowledge and values (Lyver et al., 2015, 2016) and co-designed, implemented and monitored with indigenous people (Kuzivanova & Davidson-Hunt, 2017; Morishige et al., 2018). The lens also includes papers that engage with different ideas of societal transformation. Almada and Coehlo (2015), for example, critique the Western paradigm of development and others advocate for the idea of endogenous development, that is, a development from within a system (Apgar, Ataria, & Allen, 2011; Davidson-Hunt et al., 2012). Some papers show how gastronomic heritage can serve as a starting point for designing new development pathways (Turner, Davidson-Hunt, & Hudson, 2018). Another paper proposes to use the biocultural diversity concept to transform research and governance in cities (Buizer et al., 2016).

3.3 | Comparing biocultural lenses

The multivariate analysis of the lenses showed that the *biocultural conservation*, *biocultural diversity* and *biocultural history and heritage* lenses were most central to the ordination and had the strongest overlap with other lenses (Figure 4). This indicates that they are applied in a variety of settings and in different combinations with other lenses. More marginal in the ordination space were the *biocultural restoration, transformation and design* lens, the *biocultural landscape* lens, the *biocultural knowledge and memory* lens and the *biocultural ethics, rights and sovereignty* lens, indicating that their application was more distinct from other lenses. The post hoc correlation showed an increasing consideration of power, action and bottom-up governance in papers from the left-hand side (negative scores in DCA1; Figure 4) to the right-hand side of the diagram (positive scores in DCA1; Figure 4). This means very little consideration of power, action and bottom-up governance in the *landscape* lens and

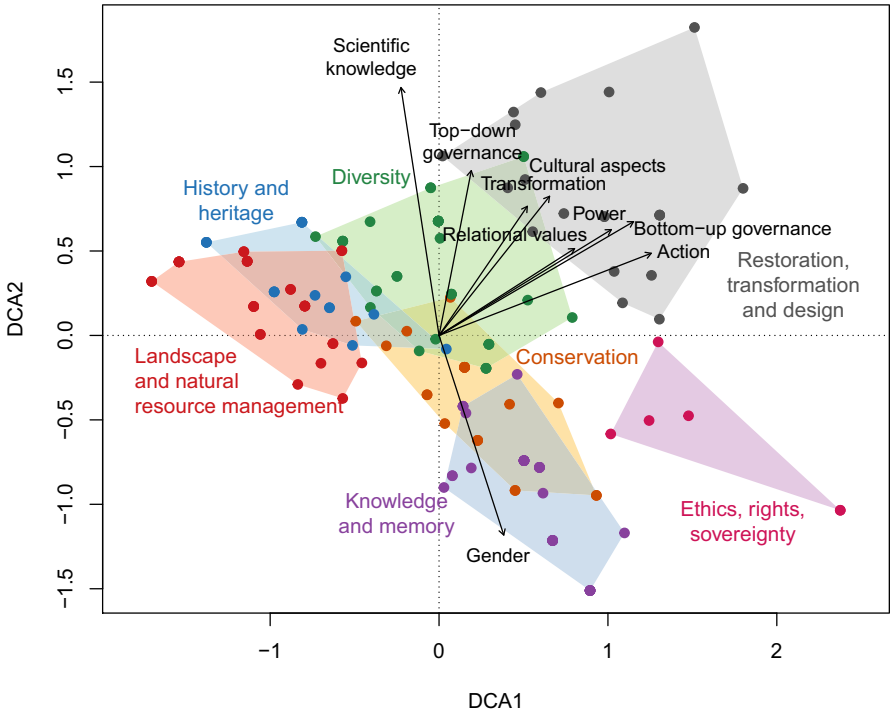

FIGURE 4 Detrended correspondence analysis (DCA) of the primary and secondary lenses of the papers. Dots represent individual papers and polygons enclose all papers belonging to a similar primary lens (coloured labels). Arrows indicate quantitative characteristics of the papers that were significantly related to the ordination space

a strong consideration in the *biocultural ethics, rights and sovereignty* and the *biocultural restoration, transformation and design* lenses. The second ordination axis (DCA2; Figure 4) was related to a gradient from a strong consideration of gender (negative scores in DCA2—papers from the biocultural *knowledge and memory* lens) towards a strong consideration of scientific knowledge and top-down governance (positive scores in DCA2—papers from the *biocultural history and heritage*, the *biocultural diversity* and the *biocultural restoration, transformation and design* lenses). Furthermore, the top-right corner of the ordination, that is, the *biocultural restoration, transformation and design* lens, is characterized by a stronger consideration of cultural aspects and transformation.

In terms of the disciplines engaged there was the strongest association between agriculture, forestry and veterinary medicine and geosciences with the *biocultural landscape* and the *biocultural diversity* lenses (Figure S2). Most distinctly, there was a strong engagement of biology, but also the humanities with the *biocultural knowledge and memory* and the *biocultural conservation* lenses.

4 | DISCUSSION

Through this review we have identified seven different biocultural lenses as ways of how biocultural approaches to sustainability are applied in the scientific literature. Through a combination of qualitative and quantitative methods, we provide a multifaceted characterization of these lenses. In the following paragraphs, we discuss our findings and assess their implications for future research in sustainability science. We base this discussion on how these diverse biocultural approaches to sustainability relate to key components of sustainability science (Kates et al., 2001; Miller et al., 2014) as follows: (a) the adoption of a systems perspective on human–environment interactions, (b) the implementation of inter- and transdisciplinarity and (c) the commitment of providing solutions to sustainability issues.

4.1 | Social–ecological systems perspective in biocultural approaches to sustainability

Sustainability science recognizes the tight coupling between humans and their environment within a complex, adaptive system which requires a holistic approach for studying it (Folke, 2006). Biocultural approaches by definition take such a social–ecological systems perspective (Maffi, 2005). They have been developed to interpret and represent the diversity of worldviews on human–environment interactions to overcome dominant western dichotomous and reductionist's views on nature and culture (Caillon et al., 2017). By acknowledging the inseparable link between nature and culture, the concept has a deeply ingrained systems perspective at its core, thus making it an inherently social–ecological systems view (Liu et al., 2007).

Our findings show the uptake of such a social–ecological systems perspective in different regards. In the reviewed papers, we generally observed a rather balanced consideration of biological and cultural issues and only rarely papers were narrowly limited to specific questions that lacked a systems perspective. Furthermore, the lenses we identified show that biocultural approaches cover a broad range of applications across different contexts. Such applications include applied research ranging from biodiversity conservation and ecosystem restoration to discussions of ethical issues and their implementation in transformational research. These lenses were not exclusive to each other and a considerable overlap

across the different topics and perspectives was evident. Most clearly, this is illustrated by papers that showed strong linkages to multiple lenses and that were difficult to assign to a single primary lens, thus indicating a strong potential of biocultural approaches to bridge topics. For example, Turner et al. (2018) assess how local food products and gastronomic identities of a region can be used to achieve sustainable development trajectories, linking the *heritage* lens with the *restoration, transformation and design* lens. In addition, several papers connected the biocultural diversity lens with other lenses, such as Brosius and Hitchner (2010) to the *conservation* lens, Fukamachi et al. (2011) to the *landscape* lens and Plieninger et al. (2018) to the *restoration, transformation and design* lens.

Furthermore, we commonly found that applications of biocultural approaches study human–environment relationships in particular places with a consideration of interactions across spatial and temporal scales. The majority of the reviewed papers were place-based, empirical case studies. A (spatial) delineation of system boundaries can ease the implementation of a systems perspective. Such a delineation was frequently given through a landscape approach (especially in the *landscape* lens) which closely links to other concepts such as cultural landscapes, that is, landscapes resulting from a long human–environment interaction (Plieninger et al., 2015) and other fields of research, such as landscape ecology (Wu, 2013). Besides spatial patterns and scales, temporal dimensions are key to biocultural approaches and their application. Conceptually, the idea of a potential co-evolution of biological and cultural aspects puts emphasis on the temporal dimensions and dynamics, particularly for biocultural diversity. This is specifically reflected in two of the lenses (*knowledge and memory* and *history and heritage*), as well as in individual, often empirical publications on historical dimensions, legacies and memories (Cevasco et al., 2015).

4.2 | Inter- and transdisciplinarity in biocultural approaches to sustainability

The uptake of a systems perspective in sustainability science, as described in the previous section, requires the consideration of knowledge and methods from different disciplines. In the biocultural lenses, such interdisciplinarity is visible through the broadness of topics that emerge from the cross-disciplinary engagement of scholars. Importantly, many of the represented research communities consider themselves as inherently bridging between disciplines. This includes, for example, the discipline of ethnobiology (Wolverton, 2013) or landscape research (Wu, 2013).

Next to interdisciplinarity, a genuine engagement with non-academic actors, that is, transdisciplinarity, is key to sustainability science (Brandt et al., 2013). Biocultural approaches have arisen from such engagement with non-academic actors and the implementation into policies (Merçon et al., 2019). We suggest that biocultural approaches have served both as a boundary concept, when applied to conceptually or theoretically interpreting human–nature relationships, as well as a boundary object, when applied in practice and action-oriented initiatives. This flexibility of meanings and applications has the potential to be very useful in ongoing and future research in sustainability science. In fact, collaboratively defining boundary objects has been proposed as one important step for achieving transdisciplinarity in practice (Lang et al., 2012). A boundary object is an entity that is shared by several different communities but viewed or used differently by each of them (Star & Griesemer, 1989). That means that a boundary object has an 'interpretive flexibility' which is able to satisfy the needs of users from different social worlds while facilitating communication between them (van Pelt et al., 2015; Star & Griesemer, 1989; Steger et al., 2018), allowing for cooperation and interdisciplinarity without the need for consensus (Baggio, Brown, & Hellebrandt, 2015; Star, 2010). Biocultural approaches in this review have featured interpretative flexibility and divergent understandings and applications across fields and facilitate communication and collaboration across different communities of practice (Steger et al., 2018; Wenger, 1998). However, at the same time this review also indicates very little implementation of the principles of transdisciplinarity in the scientific publications analysed, which can undermine the full potential of biocultural approaches in research for sustainability. Elsewhere it has been shown that biocultural approaches have partly arisen from such transdisciplinary engagement with practitioners and indigenous rights movements in intergovernmental environmental bodies such as the CBD and IPBES (Merçon et al., 2019). In such practice contexts, the incorporation of the biocultural diversity concept was highly contested, for example, in the IPBES negotiations for the pollinator's assessment (Schmeller & Bridgewater, 2016). This might suggest that while on the one hand conceptual vagueness is necessary for boundary concepts to bridge, integrate and connect different disciplines, values, knowledge systems and practices (Steger et al., 2018), it can, on the other hand, lead to a lack of focus, cause misunderstandings and even jeopardize its application in policy and management.

4.3 | Sustainability solutions through biocultural approaches

At the core of sustainability science is the desire to provide actionable knowledge that can contribute to solving sustainability problems. Biocultural approaches can blend into such solution-oriented research in different regards. For example, they can serve for defining indicators of sustainability (Sterling et al., 2017) or facilitate transformational processes (Elands & van Koppen, 2012). In this review, we analysed how biocultural approaches linked to SDG. We selected the SDGs as one possible set of goals. The SDGs were approved in 2015 by the General Assembly of the United Nations and aim at updating a universal agenda, building upon the Millennium Development Goals, towards an integrated balance between the economic, social and environmental dimensions of sustainable development (UNGA, 2015). In our exploration of the relationships

between the biocultural literature and SDGs, SDG15 (i.e. to 'Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification and halt and reverse land degradation and halt biodiversity loss') was most prominently linked to biocultural approaches. However, having only identified the main SDG related to each paper, our findings do not allow for a more nuanced overview of secondary links between biocultural approaches and SDGs. Interestingly, 28 papers did not relate, even indirectly, to any particular SDG. By that, our findings eventually reinforce Poole's (2018) idea that the SDGs still neglect fundamental qualities of cultural sovereignty, which are key in maintaining sustainable practices, values and lifestyle habits and that an 18th goal, which acknowledges biocultural heritage, should be included. It is argued that while sustainability is largely a matter of culture (Soini & Dessein, 2016), neither local ecological knowledge, cultural values and alternative economic practices, nor their interrelation with biodiversity are currently mentioned by any SDG in the pathway to sustainability (Poole, 2018). Instead, a universal agenda for sustainability should acknowledge and accommodate diverse worldviews and value systems around the notion of 'development' and alternative ways of framing nature–society relationships (Kopnina, 2016; Menton et al., 2020; Otero et al., 2020), within which biocultural approaches have even been posed as potential basis for the improvement of sustainability indicators (Sterling et al., 2017).

These findings are nuanced by the outcome that important issues particularly related to social sustainability and justice have not been extensively taken into account in the application of biocultural approaches thus far. Only two-thirds of the papers consider power and less than a quarter engage with gender issues, where gender is often connected to gendered knowledge and not to social justice-related issues. When it comes to engaging with sustainability solutions, two main types of studies in biocultural approaches can be distinguished. First, publications and lenses that more or less explicitly emphasize conservation as a key strategy for future engagement. Conservation focuses on the maintenance of different manifestations of traditional, indigenous or local human–nature relationships (particularly in the *conservation, history and heritage* and the *diversity* lenses) and often applies biocultural approaches as a descriptive and analytical entry point to investigate social–ecological systems. For example, biocultural diversity is often described empirically, under the premise that it has an intrinsic value, which needs to be preserved. Second, papers and lenses focus on transformation, that is, on leveraging biophysical and societal changes in a given social–ecological system to foster sustainability (e.g. *restoration*, *transformation and design* lens). Interestingly, many more papers (and lenses) tend to have a descriptive perspective on how a co-production of nature and culture has led to certain biocultural phenomena in the past and consequently emphasize a solution-oriented pathway to conservation. However, lenses rarely engage in a forward-looking perspective with action, transformation and a more dynamic and adaptive notion of biocultural approaches.

The different emphases of the lenses might be relevant for different situations, as they provide different entry points—some have greater salience to certain problems or decision contexts as compared to others. For example, in social–ecological systems subject to rapid environmental change, biocultural restoration may be the most suitable starting point, whereas in social–ecological systems, where the emphasis is on knowledge weaving and the rights of all people involved, a biocultural ethics framing may be more appropriate. However, the dominance of a 'nostalgic' perspective that is more centred around conservation might reduce the ability to adapt to future challenges. Also, the conservation focussed lenses tend towards a narrower problem framing and a more descriptive analysis, while the transformation point of view tends to take the broader perspective requiring systemic change for solving problems, thus emphasizing more strongly the dynamic nature of biocultural relationships. In this regard, the latter lenses are more representative of what sustainability science stands for—that is to take a systemic perspective to solve sustainability issues through transdisciplinary approaches. Our review suggests that biocultural approaches in sustainability science need to move from describing how nature and culture are co-produced to co-producing knowledge for sustainability solutions. For this, there is a need to take into account questions of power, gender and transformations, which has been largely neglected so far.

5 | CONCLUSIONS

Biocultural approaches embrace many features that render them suitable for application in sustainability science. They provide the conceptual and practical space for the inclusion of different academic disciplines and non-academic views and perspectives alike. However, biocultural approaches still lack mainstreaming of issues related to gender, power, action and transformations. More attention is needed in this regard in future applications in order to bring biocultural approaches to their full potential for sustainability science, so that they are not only implemented in an emancipatory and potentially transformative way in policy processes, but also in sustainability research.

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CONFLICT OF INTEREST

The authors declare no competing interests.

AUTHORS' CONTRIBUTIONS

All authors reviewed the literature and coded the articles; A.S.O., N.M.G., C.M.R. and J.H. conducted the qualitative analysis; J.H. performed the quantitative analysis and prepared the figures. All authors contributed to the design and writing of the manuscript.

DATA AVAILABILITY STATEMENT

Data are available via the Dryad Digital Repository https://doi.org/10.5061/dryad.d51c5b007 (Hanspach et al., 2020). The 178 reviewed papers are listed in the Data Sources section.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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